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Eos VISIBLE IMAGERS

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I am head of the Sensor Concepts and Development Branch, Goddard Space Flight Center. I have been working with the Moderate Resolution Imaging Spectrometer, (MODIS) for nearly 5 years. Dr. Wayne Esaias and I initiated the MODIS Instrument Panel in 1984. In the last year or two, the branch has expanded its Eos responsibilities to include the Geoscience Laser Ranging System (GLRS). We are monitoring dual Phase-B studies on both MODIS and GLRS. This paper, however, will examine some of the proposed Eos optical imagers. Table 1 is a list of the imagers and their acronyms. In addition to MODIS-N (Nadir) and -T (Tilt) in the class of facility imagers, there are the High Resolution Imaging Spectrometer (HIRIS) and the Intermediate Thermal Infrared Radiometer (ITIR). Principal Investigator (PI) instruments include the Multi-Angle Imaging Spectrometer (MISR), from JPL, the polarimeter (EOSP), and the Lightening Imaging Sensor (LIS). A summary of these sensors is given in Table 2. In the table, TL/PI refers to the Team Leader for facility instruments and PI is the Principal Investigator.

The spectral range of MODIS-N ranges from 0.4 to 14 microns in some 40 spectral bands. MODIS-T is a true spectrometer with 10-nanometer bandwidth spanning from 0.4 to 1 micron in 64 bands. The Instantaneous Field of View (IFOV) of MODIS-N ranges from 250 to 1000 m. That is not quite true in that the IFOV was 250 to 1000 m when the Eos altitude was 800 km. When it was reduced to 705 km, NASA Headquarters requested that we maintain the same angular IFOV. Therefore, the footprint on the ground is now 214, 428, and 856 m and the swath is 110^0. We have maintained MODIS-T at a 1000-m IFOV and 90^0 swath. HIRIS has 192 spectral bands, 30-m spatial resolution, and approximately a 2^0 or 24-km swath. The MISR's swath is 200 km and has a 1.7-km IFOV. By cutting down on the swath, the MISR can go to a 200-m IFOV, so there is a way of getting high resolution on an occasional basis. More detail on some of these sensors will be given later. The Earth Observing Scanning Polarimeter (EOSP) has a 10-km IFOV and a 100^0 swath, which is the same as MODIS-N, and 12 spectral channels.

Marshall Space Flight Center's instrument, the LIS, is a single-channel, 10-km IFOV sensor with a 42^0 swath, which results in 550 km on the ground. The Japanese ITIR will have 11 bands between 0.9 and 12 microns. With 15- and 60-m resolution, this is the highest resolution imager on Eos. ITIR's swath is either 30 or 75 km and can be varied according to the mission requirements. Lines 8 and 9 of Table 2 show whether or not the instrument can point alongtrack or crosstrack.

MODIS-N is strictly nadir pointing but it scans 2300 km crosstrack so there is no need for crosstrack pointing. MODIS-T does point plus or minus 50^0 alongtrack. It has a wide swath so crosstrack pointing is not necessary. HIRIS points both crosstrack and alongtrack. This allows it to view any area within the MODIS-N and -T swath. By pointing side-to-side, it can pick out any spot on the Earth within a 2-day period. The MISR instrument does not move; instead, it has 8 cameras with fixed fore and aft pointing angles. None of the other sensors point except the ITIR, which has one fixed-angle pointing channel for stereo data. The data rates presented in the case of MODIS are buffered rates for daylight operation. During the daylight, MODIS-N is putting out about 15 megabits per second. Approximately 40 percent of the

orbit is in daylight. During the 60 percent that is night, only the thermal channels are output. MODIS-T also operates 100 percent of the daylight with an output of about 7 megabits per second and is shut off at night. There will be stored commands to go from daylight to dark on both instruments. We will also have stored commands on MODIS-T for pointing. That is about all of the commands needed except for turning various channels off in case something happens to them.

Question: Will the daylight channels of MODIS-N be turned off during the night portion of the orbit?

I suspect we will leave them on and just reconfigure the output buffer so that we only ingest the nighttime channels.

Question: Will the HIRIS channels be turned on only as they are needed?

I do not know about HIRIS, but my guess is that they will leave them on at all times and only select those channels that they want. HIRIS has data restrictions, but I believe they are strictly data volume. I do not believe there is a power problem. HIRIS is limited to about 3.4 megabits per second, long term average, and 10 megabits per second average in any one orbit, which is about a 3 percent duty cycle. The rest of the data rates in Figure 2 are small except for the ITIR, which will output 55 megabits per second due to its high spatial resolution. The PI sensor duty cycles are to be determined, depending on operational constraints.

Question: Is MODIS digitized to 10 bits?

No. MODIS-N is 12 bits and MODIS-T is 14 bits. Fourteen bits for MODIS-T is required because of the very high dynamic range needed for it to view both land and oceans, whereas MODIS-N contains separate ocean channels and land channels, each with their individual dynamic range. Therefore, not as much digitalization is needed as is required for MODIS-T. The 14-bit digitizer on MODIS-T could be replaced with a 12-bit digitizer and commandable gain changes, but that approach results in a considerable increase in complexity, and the slight increase in data rate resulting from a 14-bit digitizer was viewed as a small price to pay for the decrease in sensor and operational complexity.

MODIS-T is an imaging spectrometer consisting of a 64-by-64 detector array, a collecting telescope and mirror. A parametric summary, a system schematic, and an optical schematic are shown in Table 3 and Figures 1 and 2, respectively.

Question: What is the spectral range and bandpass of the 64 channels of MODIS-T?

They are nominally 10-ns wide and range from 0.4 to 1.04 micrometers. They probably will not be exactly 10 nm, but will be closer to 9.8 nm depending on the final design. It is very much like HIRIS, the spectrometer that spans the visible near infrared (NIR) and shortwave infrared (SWIR) spectrums.

Question: Will channels be selected on-board for transmission to the ground?

Earlier in the design phase, we decided that rather than trying to pick out channels and send them down, it would be easier to send them all and sort them out on the ground. The biggest requirement from the instrument panel was 17 channels for ocean bioproductivity. The ocean scientists had a reason for each of the 17 channels

and at one time we considered a sensor with 17 maximum channels. With the spectrometer approach, it was deemed simpler to transmit all channels.

Question: Is the MODIS spatial resolution constant across the swath?

There is no attempt to make a constant IFOV cross-scan. We selected a whiskbroom scanner that expands the IFOV as we go crosstrack, resulting in 2 1/2-km pixels near the ends of the swath.

Question: What are the system drivers for MODIS-T?

The absolute accuracy of 2 percent is very tough; nobody has ever done that. We also have a very strong requirement that the instrument not polarize incoming, unpolarized radiance any more than 2 percent at all scan and tilt angles. That is equally tough.

MODIS-N is an imaging radiomonitor, not a spectrometer like MODIS-T, with 250-m spatial resolution in two channels, 500 m in 12 channels and 1000 m in 20 channels. We are also looking at expanding two of the channels' dynamic ranges so that we can look at fires. Ordinarily they would saturate, if there is any appreciable area of fire in the pixels. By looking at the amplitude, one can determine what part of the pixel is covered by the hot object. The range expansion will be attained using nonlinear digitalization. We keep a total of 12 bits but make the upper bits (higher temperatures) respond at a lower gain.

Question: Will MODIS be capable of measuring the thermal signature of power stations?

Probably, since the temperature resolutions are around 0.05°. If the power station outflow is spread over a 1-km pixel it will probably raise the temperature a tenth of a degree or more. It is difficult because it will integrate the output over the 1-km pixel.

Question: Does MODIS operate at night?

Yes, you can see a lot in the thermal bands at night. It is going to be the same or better than Advanced Very-High-Resolution Radiometer (AVHRR).

MODIS-T is basically an ocean color instrument because of its tilting capability. The primary goal of MODIS-T is to measure global ocean color. There are also eight ocean color channels in MODIS-N that allow it to pick up some of the data missed when MODIS-T is changing tilt angle. During that tilt maneuver, MODIS-T misses a large amount of data. MODIS-N will be able to acquire data from that side of the swath which is not contaminated by glint. MODIS-N also has most of HIRIS channels and will be able to gather data for moisture and temperature profiles. The sounding data will be at 1-km spatial resolution, which has never been done. This will allow the atmospheric scientists to examine severe storms at a spatial resolution unavailable previously.

Question: What is the major improvement in sounding when comparing HIRIS to MODIS-N?

HIRIS samples every 14 km, while MODIS-N will develop a 1-km resolution sounding image.

Question: At 1-km resolution, can the thermal channels detect hot spots such as forest fires?

There is going to be some confusion. That is, a warm city and a small fire may be indistinguishable. They average out and you won't be able to tell the difference.

Question: But, won't you be able to distinguish by location?

Yes, if you are out over the rain forest in Brazil and you see something hot, you can be pretty sure that somebody is burning forest. However, if you are over New York City, it could be someone burning New York City.

Table 4 lists HIRIS functional parameters. HIRIS is an imaging spectrometer that covers the spectral range from 0.4 to 2.5 micrometers in 192 bands, with 3 sets of 64 bands in each spectrometer. The spectral resolution will vary because they are using prisms, which change dispersion with wavelength. The pointing, as shown in Table 4, is +52 and -30^{0} alongtrack, and crosstrack is $\pm 26^{0}$. The 280-MBPS output rate is determined by the Tracking and Data Reply Satellite System (TDRSS) high data rate limitation of 300 MBPS. HIRIS will enable a variety of remote sensing sciences. The main reason is that in the 2- to 2-1/2 micrometer spectral region, there are numerous features that allow one to identify geological features. Dr. Goetz has been working in that area for a long time using aircraft instruments, including Infrared Imaging Spectrometer (IRIS) and Advanced Visible Infrared Imaging Spectrometer (AVIRIS) that are out of JPL. For accurate calibration, the scientists want the sensor to look at onboard solar diffuser targets, the Moon, onboard lamps, absolute detectors, and instrumented ground targets. One must use as many techniques as possible to get the absolute calibration to below 5 percent and, hopefully, as low as 2 percent.

Table 5 lists some of the attributes of the MISR, a PI instrument developed by JPL. Figure 3 shows a conceptual view of MISR. The system consists of 8 cameras with 4 pointing ahead and 4 pointing aft. The pointing angles are 25, 46, 60 and 72.5^{0}. Each camera has 4 spectral bands with wavelengths from 0.4 to 0.86 micrometers. The main purpose of MISR is to develop atmospheric corrections for the Eos users.

Additional uses for MISR include cloud classification, cloud structure, etc. The spatial resolution is ordinarily 1.7 km, a bit coarser than MODIS.

Question: Will MISR be used mainly to support HIRIS?

No, because HIRIS has 30-m spatial resolution, and MISR a 1700-m resolution. MISR will be used to correct the wide field scanners, like MODIS using wide field atmospheric corrections. Nobody has been able to perform quality atmospheric corrections routinely except over the oceans for ocean color corrections. Atmospheric corrections over land are difficult.

The Eos photopolarimeter, shown in Figures 4, 5, and 6, is a low-risk instrument with 12 spectral bands going from 0.4 to 2.2 microns with 10-km spatial resolution. The scanner consists of two mirrors that cancel out the polarization caused by the scanner. The mirrors cross in such a way as to cancel the polarization from the scan system. Polarization caused by the scan mirror is a problem, and EosP has solved that problem. An instrument similar to EosP has flown to Mars. Two or three of these have flown on planetary probes. They are well developed and are, therefore,

rather low risk. The problem with polarization measurements is that both the atmosphere and the ground polarizes, and the sensor is looking at both. The observer has to separate them, which is difficult. However, it may be possible to separate the two components by examining the spatial scale of the ground signal compared to that of the atmosphere.

The ITIR is interesting because it is a high-resolution thermal instrument (see Table 6). Dr. Anne Kahle of JPL has been working with an airborne sensor called TIMS and has proposed TIGER, which is the Eos version of TIMS. She has been selected to incorporate some of her thoughts and some of her results into the Japanese ITIR. She has gone to Japan to disuss this. It remains to be seen what ITIR will look like after incorporating some of the TIGER channels.

MODIS-T is basically finishing up Phase B. The Phase-B studies of MODIS-N with Perkin Elmer and SBRC will be completed in July 1989. The Phase-C/D RFP will be released in November and hopefully MODIS-N will be under contract within 10 months to 1 year after that, which would result in a start in October 1990, which coincides with the proposed Eos FY91 new start.

Question: Where will the Eos data be processed?

The ground rules under which we are operating are that all the processing through Level 1 will be done at the Eos Data Information System (EosDIS). In the case of MODIS, the 24 Science team members are supposed to supply Level 2 and 3 algorithms ready for use by EosDIS. However, we are working hardest on trying to calibrate and locate the data for Level 1 to make sure that it is the best it can be and then, if somebody wants to take Level 1 data and do their own Level 2 and/or Level 3 products at their own facility, fine. Our major concern is to get to Level 1.

Question: How will HIRIS limit their output to 280 MBPS?

They are going to do two things: channel selection and swath width selection. They will narrow the swath to less than the present 24 km. The swath is viewed by four butted detector arrays. On command, the outer arrays can be deleted, resulting in a 12-km swath. In some cases, all channels can be viewed over a narrow swath or in other cases, a few channels can be imaged over the full 24 km. The data from MODIS-N and -T are approximately 700 gigabits a day. MODIS generates more data than HIRIS because of its 100-percent duty cycle. The MODIS data volume is 600 computer tapes a day for 15 years. The HIRIS duty cycle is only about 3 percent. The total for all of Eos is a Terabit a day. MODIS is a big part of the total. An optical disk juke box holds 48 twelve-inch optical disks. MODIS fills up one of these each week. GSFC management has requested a building of 150,000 square feet for EosDIS, of which 50,000 square feet is to store data. A 150,000 square foot building will be one of the largest buildings at GSFC.

Question: Does MODIS process the data onboard?

We have been asked to packetize the data. In addition to packetization, we must buffer the data and send it to the data system on the platform. How we do that is left up to us, and we are trying to arrive at a design now. For instance, we would like for each packet to contain only one channel with an identifier so that the data stream on the ground can be examined and a given channel extracted.

Question: How do MODIS and HIRIS interact?

There has been some synergism studies. There is interest in the ground data systems as to what parts are common between HIRIS and MODIS, and whether there are possible savings. There probably are, and we have tried to look at this commonality. We have had some meetings between Dr. Goetz and the MODIS people, and he was on the MODIS Instrument Panel. If there is any onboard coordination it probably should be at the HIRIS end, since MODIS runs 100 percent of the time, and it will be up to HIRIS to grab the required data. Once the MODIS data gets to the platform, if HIRIS wants to route part of it through the LAN to HIRIS, this is possible. But I don't know if it has been requested.

Question: How would an instrument PI on Eos go about getting data from another sensor on the platform?

He would have to make a request to the Eos project, and I don't know of anyone who has done this at this time.

Question: How are the sensors controlled on the platform?

The platform has a large number of stored commands. How they distribute those commands is to be determined.

Question: How does an experimenter interact with the EosDIS data set?

The experimenter is supposed to be able to dial up the system, find out what data is available, and find where the data is. How the data will be distributed to the experimenter is to be determined. Possibly, they will distribute the data over the wire, or they will use the mail system. There will be a lot of routine data products and I think I will leave it to Dr. Esaias to talk to some of those. But, if you are looking for a weekly average of a parameter, EosDIS may be generating that and it may send it to you in a composite form once a month. You can ask for a routine distribution of that type of data and they will probably mail it to you. In some ways that is still to be determined. The Eos Project is in the middle of Phase-B studies for EosDIS and they have a structure review in the next month or two where they will start laying out what the hardware looks like and how they are going to use it.

Question: How long will it take for EosDIS to process the data?

They advertise 48 hours to Level 1 and 48 more hours to Level 2 and 3.

Question: Will all of the data be processed in these time periods?

It turns out that it is not very realistic if you need a second instrument's data to help generate it. In other words, if you need HIRIS data to make a data product from MODIS, you are going to have to wait 48 hours or 96 hours for the HIRIS Level 3 to come out and feed it back into the MODIS data. If all the data you need is from your instrument and you don't need outside data, even though it may be routinely available, then the 48- and 96-hour times are probably realistic.

Table 1. Eos Optical Imager Acronyms

Facility Imagers

MODIS-N	Moderate Resolution Imaging Spectrometer-Nadir
MODIS-T	Moderate Resolution Imaging Spectrometer-Tilt
HIRIS	High Resolution Imaging Spectrometer
ITIR	Itermediate Thermal Infrared Radiometer

Principal Investigator Imagers

MISR	Multi-angle Imaging Spectro-Radiometer
EOSP	Earth Observing Scanning Polarimeter
LIS	Lightning Imaging Sensor

Table 2. Summary of Eos Optical Imagers

	MODIS-N	MODIS-T	HIRIS	MISR	EOSP	LIS	ITIR
TL/PI	V. Salomonson	V. Salomonson	A. Goetz	D. Diner	L. Travis	H. Christian	A. Ono
Sponsor	GSFC	GSFC	JPL	JPL	GSFC	MSFC	Japan
Spectral Range (μm)	0.4-14	0.4-1.0	0.4-2.5	0.4-0.9	0.4-2.3	0.8	0.9-12
Bands	40	64	192	4	12	1	11
IFOV (m)	1000, 500, 250	1000	30	1730	$1x10^4$	$1x10^4$	15, 60
Swath (degrees)	110	90	2	30	110	42.4	2.5, 6
Swath (km)	2330	1500	24	210	2330	550	30, 75
Pointing							
Alongtrack	N	Y	Y	Y	N	N	Y
Crosstrack	N	N	Y	N	N	N	N
Data Rate (MBS)	15	7	280	2	0.08	0.003	55
Duty Cycle (%)	100	100	3	TBD	TBD	TBD	TBD

Table 3. MODIS-TILT (T) Summary

PARAMETERS	EXPECTED PERFORMANCE
PLATFORM ALTITUDE	705 KM
IFOV	1.4 MRAD (1KM)
SWATH	90 DEG/1500 KM
SPECTRAL BANDS (10 NM WIDTH)	64 (O.4-1.04 MIC.) (AREA ARRAY)
RADIOMETRIC ACCURACY (ABS) (GOAL)	+/- 2% MAX
POLARIZATION SENSITIVITY	2% MAX < 700 NM 4% MAX > 700 NM
MODULATION TRANSFER FUNCTION	0.3 AT NYQUIST (SPEC)
S/N PERFORMANCE (SPEC) (70 DEGREE SOLAR ZENITH)	500:1(405 NM) 300:1(625 NM) 150:1(825 NM)
QUANTIZATION	14 BIT
SCAN EFFICIENCY	50 %
INTEGRATION TIME	4 MSEC
COLLECTING APERTURE (DIA)	50 MM
OVERALL DIMENSIONS (APPROX)	TBD
WEIGHT	TBD

Table 4. HIRIS Functional Parameters

DESIGN ALTITUDE	705 KM
IFOV	30 M
SWATH WIDTH	24 KM
SPECTRAL COVERAGE	0.4 - 2.5 UM
AVERAGE SPECTRAL SAMPLE INTERVAL	
0.4 - 1 UM	9.4 NM
1 - 2.5 UM	11.7 NM
POINTING	
ALONG-TRACK	$+52^\circ/-30^\circ$
CROSS-TRACK	$+26^\circ/-26^\circ$
ENCODING	12 BITS/PIXEL
MAXIMUM INTERNAL DATA RATE	405 MBPS
MAXIMUM OUTPUT DATA RATE	280 MBPS
IMAGE MOTION COMPENSATION	GAIN STATES OF 1 (OFF), 2, 4 AND 8

Table 5. MISR Instrument Description

- 8 separate multispectral pushbroom cameras providing 8 different viewing geometries

  View angles: 25.8°, 45.6°, 60.0° and 72.5° both fore and aft of nadir

  Spectral bands: (1) 440 nm, (2) 550 nm, (3) 670 nm, (4) 860 nm
- Refractive camera design
- High dynamic range and high signal-to-noise ratio obtained using a mosaicked 4 x 2048 pixel CCD detector array in each camera
- Redundant absolute calibration using

  Deployable solar diffuser panel (the only moving instrument part)

  Stable self-calibrating QED photodiodes

Mass: 75 kg Volume: 0.5 m^3 Power: 77 W avg, 95 W peak

- Scenes composed of 32 images
  - 8 viewing geometries in 4 spectral bands
  - Data frame ("granule") covers 210 km (crosstrack) x 334 km (downtrack)
- Uniform ground sample spacing and cross-track resolution obtained at all view angles
- Continuous daylight observations of the entire Earth without coverage gaps accomplished every 16 days
- Instrument normally operated in Global Mode (222 kbps output)
  - 1.73 km resolution
  - 60 contiguous frames from pole to pole
- Selected targets observed in Local Mode (2 Mbps output)
  - 216 m resolution
  - Normally a single frame interspersed among Global Mode frames
  - Approximately 6 targets observed per day
- Calibration observations of deployable diffuser plate acquired near north and south poles about once per month

Table 6. ITIR

Science Objectives

- Global observation of surface geology with spatially and spectrally high resolution.

Instrument Description

1) Multiple bands over wide spectral region

   1 NIR band
   5 SWIR bands
   5 TIR bands

2) Pushbroom scanning with linear array detectors.

3) Spatial Resolution

   15m (NIR & SWIR), 60m (TIR)

4) Stereoscopic viewing in the NIR.

Technical Parameters:

MASS:	290Kg
VOL:	0.96 m^3
POWER:	650W (peak)
DATA RATE:	52.2 Mb/s (peak)

Measurements:

- NIR - image and aerosol calibration.
- SWIR - mineral resources.
- TIR - mineral resources and water vapor calibration.
- Spectral Resolution: 0.5μm
- Swath: 30 or 75 km

NIR:	0.85 - 0.92μm
SWIR:	1.60 - 2.36μm
TIR:	3.53 - 11.70μm

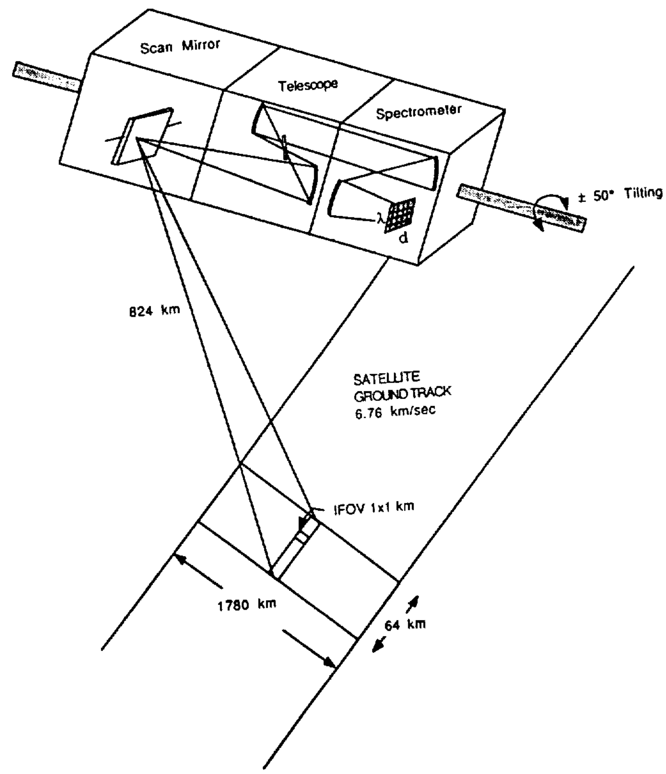


Figure 1. MODIS-T Optical Concept.

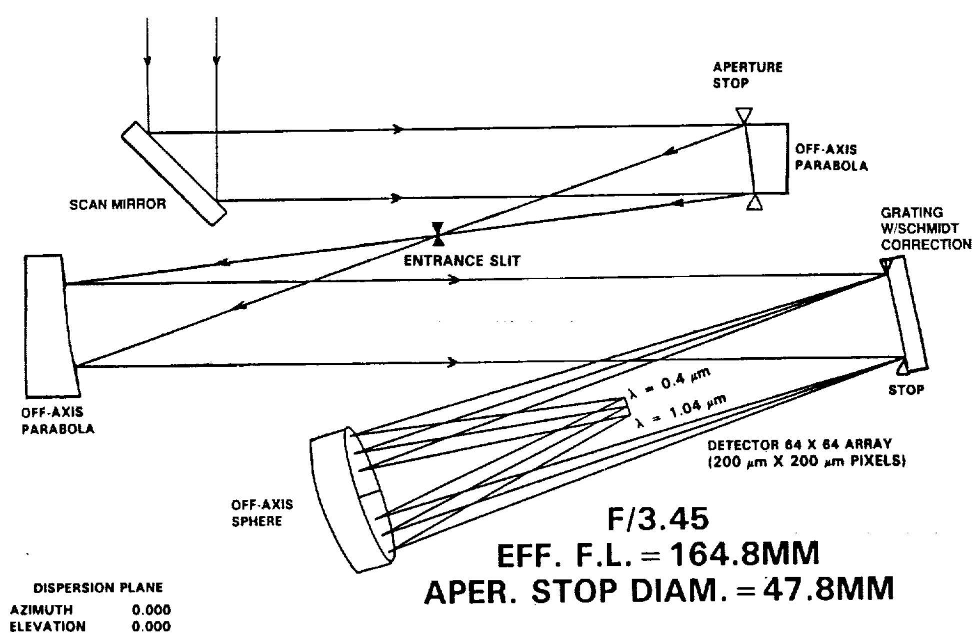


Figure 2. MODIS-T Optical Design Grating-Type Reflecting Schmidt.

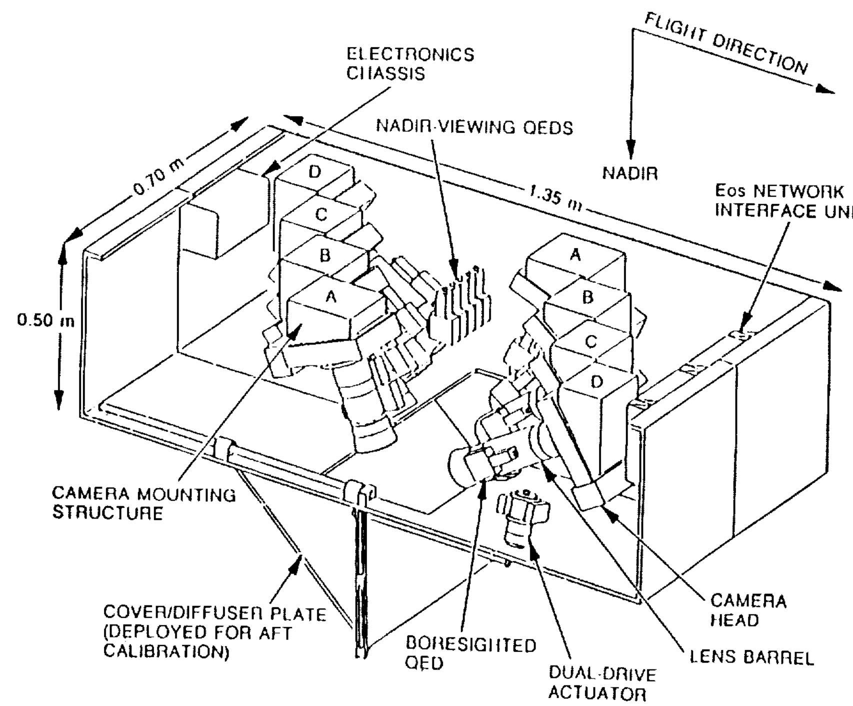
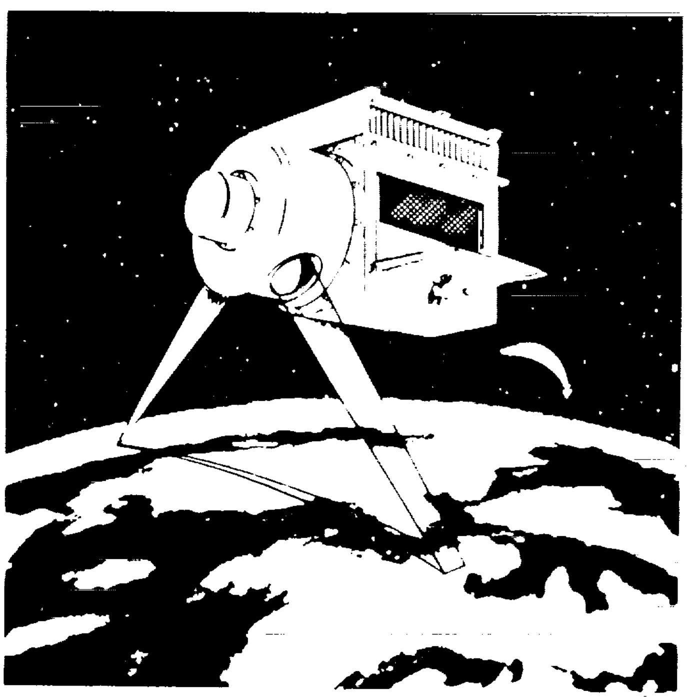


Figure 3. MISR Instrument.



- KEY MEASUREMENTS:
  - CLOUD MAPS: OPTICAL THICKNESS, PARTICLE SIZE AND CLOUD TOP PRESSURE
  - AEROSOL MAPS: GLOBAL DISTRIBUTION AND OPTICAL THICKNESS
  - POLARIMETRY INFORMATION FOR VEGETATION AND OTHER LAND-SURFACE RESEARCH
- CORRECTION PARAMETERS FOR EOS:
  - MAPS KEY INPUTS FOR ATMOSPHERIC CORRECTION MODELS:
    - SINGLE-SCATTERING ALBEDO
    - MEAN PARTICLE SIZE
    - REFRACTIVE INDEX/AEROSOL OPTICAL THICKNESS
  - COMPLETE ALGORITHMS/USABLE DATA TO BE DEVELOPED FOR SCIENCE COMMUNITY
- LOW-COST, LOW-RISK COMPLEMENT TO EOS FACILITY SENSORS
  - 12 VISIBLE, NEAR AND SHORT IR BANDS
  - PROVEN TECHNOLOGY FROM PREVIOUS FLIGHT PROGRAMS
  - 0.03 m^3 11 kg SENSOR ENVELOPE, 11W OPERATING POWER AND 88 kbps PEAK DATA RATE
  - ± 55° SCAN, 10 km IFOV

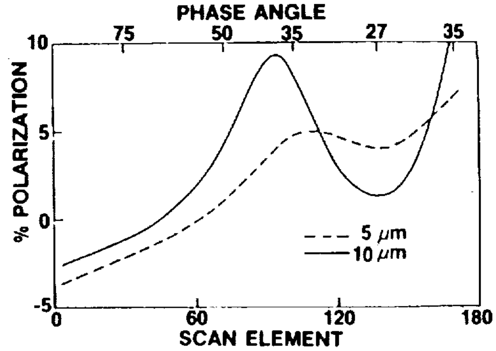
Figure 4. Earth Observing Scanning Photopolarimeter (EOSP) Offers Key Eos Measurements as Well as Correction Parameters for Other Sensors.

RELIABILITY BY DESIGN

- ± 0.1% POLARIMETRIC ERROR (SIMULTANEOUS 0°/90° AND 45°/135° POLARIZATION COMPONENTS MEASUREMENT)
- INSENSITIVITY TO DETECTOR DRIFT (INTERCHANGEABILITY OF DETECTORS FOR ORTHOGONAL COMPONENT MEASUREMENT)
- GLOBAL COVERAGE/WIDE PHASE ANGLE RANGE (LIMB-TO-LIMB SCAN)
- SMALL INSTRUMENT POLARIZATION (COMPENSATED TWO-MIRROR SCAN SYSTEM)
- < 3% ABSOLUTE CALIBRATION ERROR (INFLIGHT CALIBRATION)
- 12 BANDS SELECTED FOR MAXIMUM SENSITIVITY TO CLOUD AND AEROSOL FEATURES (410, 470, 555, 615, 675, 750, 880, 950, 1250, 1600, 2050, AND 2250 nm)

KEY COMPLEMENTARY MEASUREMENTS

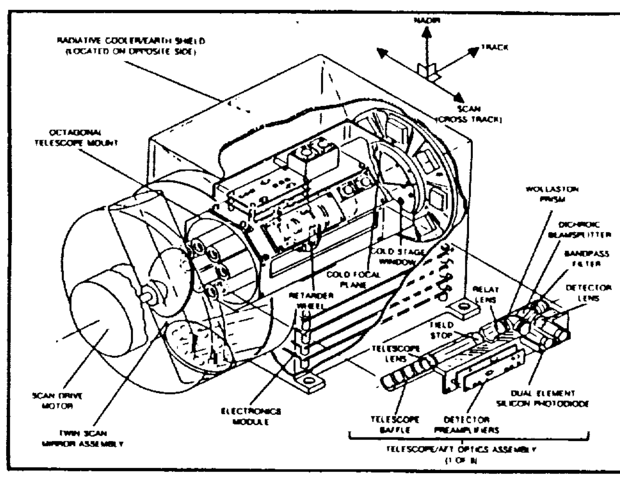
- CLOUD PARTICLE SIZE MEASUREMENT (2.25 μm)



- AEROSOL OPTICAL THICKNESS IN CLOUD-FREE REGIONS
  - BASED ON INVERSE RELATION BETWEEN POLARIZATION DEGREE AND AEROSOL OPTICAL THICKNESS
  - ACCURACY RELATIVELY INSENSITIVE TO ABSOLUTE RADIOMETRIC ERROR

Figure 5. EOSP Offers a Highly Reliable Complement to Eos Facility Sensors.

- *SCAN-METHOD:* POLARIZATION COMPENSATED TWO-MIRROR OBJECT-SPACE SCAN
- *SCENE FLUX COLLECTION:* EIGHT BORE-SIGHTED 1 cm APERTURE, f/5 REFRACTIVE TELESCOPES
- *SPECTRAL SEPARATION:* DICHROIC BEAMSPLITTERS
- *POLARIZATION:* CALCITE WOLLASTON PRISMS IN EACH TELESCOPE ASSEMBLY
- *DETECTION:* SI PHOTODIODES AND 165K PV HgCdTe DETECTORS
- *COOLING:* PROVEN SINGLE-STAGE RADIATIVE COOLER



CUTAWAY VIEW OF EOSP

Figure 6. Low Cost and Risk Hardware Design Uses Flight-Proven Technology.